SUSTAINABILITY AND SCALABILITY OF DIGITAL TOOLS FOR LEARNING: THE LEARNING TOOLKIT PLUS IN KENYA. UNDER REVIEW

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The Sustainability and Scalability of Digital Tools for Learning:

LTK+ in Kenya

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Abstract

This paper explores factors potentially powerful to increase the likelihood that a technology-based approach to teaching and learning (XXXX software) endures and expands beyond the initial research. This research evolved from a pilot study in 12 primary classes to more than 500 primary and secondary classrooms in five areas of Kenya. Based on research about scalability and sustainability of educational interventions and value-expectancy-cost theory, we designed an exploratory survey to interview a range of actors involved in the XXXX implementation. A combination of an a priori and data-driven coding approaches were used to analyse the narratives. We then built a model exploring the relationship between expectancy-value-cost beliefs and the specific factors associated with implementation and sustainability. The model explained an important portion of variance in the self-reported intent to use the XXXX with the most contribution from policies, professional development and students. These findings are important in the context where no research-proven principles exist to building sustainable and scalable educational interventions in developing countries.

Keywords: educational technology, sustainability factors, scaling, Sub-Saharan Africa

Education has been recognized worldwide as a key component of social systems that enables countries' sustainable development. To date significant progress has been made on bringing education to children. Yet, the global reference targets first set by the Millennium Goals (UNO, 2000) and succeeded by the Sustainable Development Goals (UNESCO, 2015) are not being achieved as fast and effectively as intended. According to the UNESCO monitoring report (2019), the "world is far off track" on achieving international commitments to ensure quality education for all children and youth. Globally, 250 million children lack basic literacy and numeracy even though more than half of them spent at least four years in primary school (World Bank, 2018). Research on educational practices has generated a rich knowledge base with the potential to improve teaching and learning and to optimize functioning of educational systems. However, to have real and widespread impact, the research-based strategies need to operate at scale and be viable in authentic environments of classrooms and schools. In this paper, we explore factors that have potential to increase the likelihood that a technology-based approach to teaching and learning endures and expands beyond initial research.

Related Literature

Scaling and Sustainability of Educational Innovations in Developing Context

Issues of scalability and sustainability in education are not new. Rogers' Diffusion of Innovation theory (1962), educational change (Fullan, 1982), curricular reform (Goodson et al., 1989), school change

(Argyris, 1993), and education systems change (Christensen, 1997) are just a few of the directions taken to study systemic educational improvement. In 1993, Richard Elmore analyzed the challenges involved in producing significant change in instructional quality at scale. In the field of international development, it was an influential paper by Myers (1984) that explained why going to scale is critical in order to have impact on educational policy and programming in contexts with limited resources and capacities. Since then, scaling and sustainability of successful interventions have gained a lot of traction in the global educational agenda.

However, the ever-growing body of systematic evidence on effective interventions in developing educational contexts tells little about how to make an intervention work for many and for a long time (e.g., Evans & Popova, 2016; Kim et al., 2020). For instance, the only randomized trial (Bold et al., 2018) focused on transferring a tested intervention on teacher hiring practices to national implementation. It found that the intervention produced higher student learning gains when implemented on a modest scale by an NGO rather than the government. Also, Piper et al. (2018) reported a case about bringing the large government-supported pilot to national scale. Following vertical scaling path, the reading program has been institutionalized through national planning mechanisms and involvement of national and international stakeholder groups.

Given a dearth of research on scaling educational innovations, it is the evidence generated outside education such as industry and agriculture that has been tapped for the benefit of educational systems in developing world (McLean & Gargani, 2019). However, suggesting that this knowledge is far from fully relevant to educational change, the Millions Learning report (Robinson et al., 2016) concluded that bringing to scale quality learning outcomes for children and youth continues to remain an abiding concern.

Further, scaling is only successful when sustainable; the relationship between the two has yet to be clearly articulated though. For instance, research on educational change treats sustainability as a pre-condition for scale whether small or large. Coburn (2003) insists that the scale is meaningful over time only if the implementation can be sustained in the adopting schools. The institutionalization process including rules and regulations and implementation becomes the key in order for the innovation to be integrated into the school structure and culture and to become a permanent part of it. Mioduser et al. (2004) underline the importance of the within-school spread. The big challenge in this process is to expand beyond the "islands of innovation" to "comprehensive innovation" that encompasses at least half of the teaching and learning in the school and most importantly affects its entire culture. After all, teachers are more likely to be able to sustain an intervention when it becomes the school's priority and the activities are aligned with it. This speaks to the existence of an interactive relationship between

sustainability and adoption where innovations evolve over time through modifications based on teachers' needs and beliefs (Dede, 2006). In this process teachers reevaluate the degree and manner to which innovations are implemented, balancing implementation with perceived usefulness, costs and expectations.

Value-Expectancy-Cost Framework

Based on Shepperd's (1993) motivational analysis of productivity losses in groups, authors (2004; 2006) applied expectancy theory to construct a unified view of the diverse issues that influence a teacher's decision to implement an educational innovation and persist in its use. The model posits that an educational innovation is more likely to be implemented if its perceived value and the likelihood of success are high, and if the benefits outweigh the costs of implementation. That is, a teacher's decision about whether to implement an innovation depends on how highly they value the strategy, how successful they expect it to be, and how important they perceive the costs of implementation to be. Value assesses the degree to which teachers perceive the innovation or its associated outcomes as worthwhile including benefits to the teacher (such as congruence with teaching philosophy, career advancement), and to the student (such as increased achievement, improved attitudes). Expectancy relates to teachers' perceptions of the contingency between their use of the strategy and the desired outcomes, and factors affecting these perceptions including internal attributions (such as teacher self-efficacy and skill), and external

attributions (such as student characteristics, classroom environment and collegial support). Cost relates to the perceived physical and psychological demands of implementation and operates as a disincentive to innovating and may include class preparation time, effort, and specialized materials.

Influences on Sustainability and Scale

Multiple influences may affect the delicate balance of components constituting teacher motivation to maintain improvements they achieved by implementing an intervention. The literature suggests that factors that influence processes related to implementation and sustainability are attributes of the innovation, those of its users, as well as the features of the environment including those of organization and outside them (Century et al., 2012). Having reviewed the experiences of 14 educational programs in low- and middle-income nations, Robinson et al. (2016) implies that it is the program design, delivery mechanisms, finance, and an enabling environment that are the factors of successful scaling. Evaluation research of ICT-based educational initiatives in developing countries, groups these factors into individual and organizational, technological, economic and political dimensions (e.g., Pouezevara et al., 2014). Individual and organizational dimensions relate to the individual practitioner and school capacity to sustain the intervention, as well as the organizational context encompassing leadership, school community including collegial culture and students, individual and collective capacity, ownership and expectations. Since the capacity of actors involved in implementation vary, careful attention to both

training and support is required to meet the existing needs in technical, pedagogical and content knowledge (e.g., Mishra & Kohler, 2006). Technological dimensions are concerned with the ICT needed to bring the educational intervention to teachers and students such as operation of infrastructure and equipment for the benefits of the project. Economic dimensions refer to costs and economic environment in which the innovation implementation unfolds. Political dimensions pertain to support for the intervention through local and national politics, policies and individuals.

This paper reports the study of factors that impact teacher's beliefs, attitudes and motivation to persevere in implementing a technology-based approach for instruction and its potential to endure and expand to new contexts. Namely, this approach is about teaching with the interactive software, XXXX (Authors, 2020), to promote the development of essential educational competencies in the developing context. In the status of research, the implementation of XXXX evolved from a pilot with 12 primary teachers and their 213 students (Authors, 2016) to spread to more than 500 classrooms in five regions of Kenya.

Method

Instrument

In order to explore factors influencing the XXXX use and basing on the existing research, we designed the Sustainability Interview. The funnel format of the interview allowed to obtain the

interviewees' perceptions from broader to specific ones. First, the survey was piloted with a handful of individuals involved in the XXXX implementation since the onset of the research project in Kenya; the survey was then adjusted to elicit more specific responses from the interviewees.

The current iteration of the survey begins with the two questions eliciting the interviewees' experiences with the XXXX: how they got involved with it and what they would have done differently to improve the software implementation. Then two global questions about the XXXX use are asked: a) What about the XXXX sustainability? What are the important reasons for continuing to use or stopping to use it in future? and b) What about the XXXX scalability? What are the major challenges to its widespread use in Kenya?

We consider the expectancy beliefs in the larger context of potential influences, often beyond a teacher's control. Therefore, the survey explores eight categories of influences including political factors, economic and technology factors, organizational or school factors, teacher professional development factors, software factors, individual teacher and student factors and other factors. Each question on the specific factors includes prompts to further probe respondents' thinking. For instance, the software factors question probed in the XXXX fit with the curriculum, local context of stories and activities, narration and accents, tool's interactivity, shortcomings, inadequacies and gaps of the tool(s).

Sample

Forty-three individuals participated in the interview. Three interviewees participated in both phases of the survey; their pilot interviews were not included leaving narrations of 40 respondents in the analysis. Table 1 shows the categories of respondents where school practitioners were the largest category. Of the 11 teachers, nine were active users of the XXXX, whereas two stopped using the tools. Among five school administrators, four were the headteachers in the schools where use of the XXXX continued over many years. The ambassadors were school teachers, one of them retired whereas another one became a county education quality officer. Of the seven, two were school-based and five were roving ambassadors.

Table 1. Categories of Interviewees

Interviewees	Number of completed interviews
School practitioners:	
Head teachers, Deputy head teachers	5
Teachers	11
Ambassadors (master teachers)	7
Partners:	
I Choose Life staff (county coordinators, advisor, coach)	4
World Vision	3
Aga Khan Foundation, Development Network	2
Executive officers	3
Kenya project coordinators	3
Researchers	2

Analyses

After the interviews had been transcribed, three respondents were selected at random and their responses were used to develop a coding system. At this stage, the first author developed the system and elaborated on differences between expectancy, value and cost statements. These codes and the coding system were reviewed by the three authors for finalization. Coding was completed with Hyper Research v.3.7.3. In addition to an a priori approach, data-driven codes were also generated. The second coder validated codes and their categorization on a randomly selected 10 interviews. The agreement rate evolved from 59% to reach 85%.

Next, SPSS v.24 was used to quantify and analyze the resulting data. For instance, for each of the factor categories, the sub-questions mentioned by a respondent and the valence of the response as influencing the sustainability of the XXXX were accounted for. Then, the total positive, negative, and neutral responses were cumulated across respondents. Only a single response per category and each subcategory were recorded to maintain the respondent as the unit of analysis. Multiple responses per category or subcategory were combined to reflect the coder's best impression of the respondent's beliefs. Finally, path analysis (AMOS v.26) was run to explore the relationship between expectancy-value-cost beliefs and the specific factors associated with implementation and sustainability.

Results

The findings are reported by the survey questions and followed by the results from the path diagram.

Reasons for Continuing or Stopping to Use the XXXX

All 40 respondents answered this question with each offering upto 14 ideas. According to the theoretical framework, the ideas were grouped into values, expectations and costs (table 2).

Values related to benefits teachers saw after having used the XXXX is the largest category including 140 instances. Primarily, these pertained to benefits for their students: they became more motivated (N=14), improved skills (N=12), and developed autonomy (N=12); students' absenteeism reduced (N=4). Benefits for the teachers included motivating their students (N=11) and providing an opportunity for improving teaching expertise (N=10). General advantages of the XXXX were its fit with the curriculum (N=6), comprehensiveness (N=4) and effectiveness for students of various levels and abilities (N=4).

Table 2. Summary of Codes by Values, Expectations and Costs

Categories (number of ideas)	Number of sources/respondents	Number of coding references	% of total coding references
Values	*39*	*140*	
Benefits to students (12)	32	88	62.86
Benefits to teachers (6)	21	32	22.86
General benefits (7)	16	20	14.29
Expectations	*39*	*111*	

External attributions (13)	30	61	54.95
Internal attributions (8)	26	50	45.05
Costs	*36*	*88*	
Psychological demands (5)	7	8	9.09
Physical demands (16)	35	80	90.91

Expectations were categorized in the internal or external attributes that teachers assigned in their perceptions. The most frequently reported internal attributions were "if teachers see value in using the tool" or "if the tool is not perceived as an add-on" (N=16); and if teachers are intrinsically motivated (N=10). Curiously, non-teacher interviewees indicated that technology use might be contingent on the teachers' age as younger teachers might be more tech savvy (N=5). Attributions to external sources were more frequent and related to school context: if headteachers are encouraging and do not hamper use (N=23); if support is accessible (N=13); if electricity is stable (N=12). Expectation of a financial reward was also mentioned (N=4).

Costs related to using XXXX was the smallest set including 88 instances where 91% were assigned to physical demands such as using the software outside class time since the XXXX is not part of the curriculum (N=22); having plan B if technology fails (N=15) or there is no electricity (N=9); or managing technology use in big classes (N=7).

Major Challenges to Widespread Use of the XXXX

Each of the 40 interviewees provided up to 18 ideas about the impediments to scaling the XXXX in Kenyan schools (Table 3). Unreliable technology and infrastructure in schools (N=38) and lack of

technical support at schools (N=17) were most frequently reported school-related challenges whereas rival programs and tools supported by the government (N=15) pertained to the system-related factors.

Table 3. Summary of Codes by Challenges to Scale

Categories (number of ideas)	Number of sources	Number of coding references	% of total coding references
Total	*40*	*218*	
XXXX related (3)	8	9	4.13
School-related (20)	39	100	45.87
System-related (9)	13	17	7.80
Teacher-related (24)	29	92	42.20

Among teacher-related challenges, the most frequently reported were technophobia and lack of ICT skills (N=29) and lack of interest to technology-based programs (N=19).

Political Factors

Thirty-five respondents provided between one to eight comments about political influences on viability and scale up of the XXXX tools in Kenyan schools (Table 4). Curiously, teachers offered considerably fewer opinions than school administrators and partners. Of the 121 instances, 65 pertained to the positive influences whereas 56 to the impediments. We grouped policy-related factors as related to the context for the intervention, local and national governments' engagement with the XXXX implementation and the potential outcomes of this engagement.

Table 4. Summary of Codes by Political Factors

Categories (number of ideas)	Number of sources	Number of coding references	% of total coding references
Total	*35*	*121*	

General educational system policies (20)	31	46	38.01
Local government (3)	14	15	12.4
Engaging government (5)	20	20	16.53
Benefits for the project (12)	29	40	33.06

According to the interviewees, the role of government for sustainability and scale of the intervention is paramount (N=20). Thus, the XXXX should be part of the national curriculum (N=20), included on the Kenyan cloud and authorized as the Digital Literacy Program content accessible on the government-provided tablets. However, some respondents (N=5) felt that government is protective of those initiatives they have developed from the beginning. This is why building the government's trust in the value and relevancy of the XXXX and getting them onboard is critical for sustainability and scale.

Economic and Technology Factors

All interviewees commented on the potential influences of economic and technology factors (Table 5). A computer-based pedagogical intervention might be affected by the school economies such as limited school budgets to cover expenses (N=12) and ever-growing costs such as technology repairs and electricity bills (N=13). In this context, the government's funding and support towards ICT in schools is critical (N=15), as are parent contributions to school budgets (N=11). Although funds for technology should be earmarked (N=11). Poverty as a system-related factor affecting implementation was mentioned once.

Table 5. Summary of Codes by Economic and Technology Factors

Categories (number of ideas)	Number of sources	Number of coding references	% of total coding references
Total economic factors	*35*	*88*	
System-related (5)	19	21	23.87

School-related (10)	48	67	76.14
Total technology factors	*37*	*125*	
Devices (10)	30	39	31.20
Infrastructure (5)	16	21	16.80
Support (8)	53	57	45.60
Modernization (4)	5	8	6.40

Perceptions about technology factors varied. For instance, student-computer ratio of 3 or 4 students per device seems to be an acceptable index of access to technology (N=13). One interviewee noted that this ratio was optimal in big classes where the teacher would be exhausted if she had to attend to each student working on her own device. On the contrary, this indicator was commented as too high to adequately expose their students to the tools, suggesting that it should be one student per device (N=5).

Further, instable infrastructure and electricity supply (N=13), and lack of peripheral devices/headphones (N=10) were most frequently reported to slow down implementation. The respondents' opinions about technical service and maintenance available to schools were mixed: 10 respondents were satisfied whereas 12 were not happy. Limited tech support may have impacted the choices some school administration made – some kept computers in storage as they feared to be personally accountable for broken devices.

School Factors

As Table 6 shows, the question about school and organizational factors stirred the most reactions (N=300). Each interviewee offered up to 15 ideas that pertained to leadership, concerted actions and coordinated activities on implementation, school-based expertise and available technology.

Leadership was the critical factor for implementation (N=25). Encouraging the XXXX instruction (N=14), visiting and observing classes (N=7), and following up when the XXXX is not being used and thus applying pressure to do so (N=5) are the actions expected from the school leader. To be leaders, school administrators should not only understand the importance of technologies for teaching and learning (N=14) but they need to be trained in the XXXX (N=7) and leadership strategies (N=5). Training might be a strategy to address administrators' resistance to change (N=7).

Table 6. Summary of Codes by School Factors

Categories (number of ideas)	Number of sources	Number of coding references	% of total coding references
Total	*40*	*300*	
Administration and leadership (26)	47	132	40.67
Concerted actions (23)	45	113	37.67
Scheduling (6)	20	27	9.00
Expertise (13)	25	35	11.67
Available technology (1)	1	3	1.00

It takes a whole school to implement a successful ICT programme, including a concerted effort to build ownership (N=15), collegial decision-making about its implementation (N=9) and the involvement of parents (N=16). Scheduled implementation and support activities should include uses of the XXXX whether in the school lab or regular classroom (N=11), time for teachers to learn the tools (8), to share (N=10) and to support each other (N=6). School-based ambassadors are noted as experts capable of adequately supporting implementation (N=16).

Professional Development Factors

Each of the 35 respondents shared up to 15 ideas about teacher professional development (Table 7). Interestingly, four respondents (not teachers) provided one-third of all comments. Training was reported central in the model of XXXX-related professional development (N=10). The comprehensive nature of XXXX training was noted for its potential to make up for the gaps in the DLP training and target multiple stakeholders involved in implementation, including school administrators (N=4) and ambassadors (N=6).

Table 7. Summary of Codes by Professional Development Factors

Categories (number of ideas)	Number of sources	Number of coding references	% of total coding references
Total	*35*	*131*	
Training: general (10)	14	19	14.51
Training: outcomes (16)	21	32	24.43
Training: modes (5)	19	24	18.32
Training: accreditation (4)	7	11	8.40
Follow-up support (14)	21	45	34.35

The content and desired outcomes from training have been also commented (N=32). In addition to developing an understanding of the tool and how to use it, training emphasizes the fit between the XXXX tools and other programs; training also presents the comprehensive view of the XXXX teaching logic; and improves instructional flexibility and capacity to make informed decisions about the tool to use. It targets a range of broader skills, including managing group work, teaching with ICT and reflecting on teaching.

Offering certification in XXXX pedagogy is valued (N=11) as the evidence of professional growth, as a means to promotion, with marks on teacher appraisal or as a symbolic reward. There was an expressed

need for structured follow-up (N=17) with ambassadors as the critical driver (N=9). To support teachers in small schools and remote areas, building the XXXX network was suggested (N=8).

Software Factors

In regard to the XXXX software, the interviewees' comments pertained either to a particular tool or the entire collection (Table 8). They highlighted the unique place that it takes in the instructional landscape and, therefore, its potential to bridge the existing gaps in the curriculum (N=14). Specifically, the XXXX's flexibility makes it distinct in comparison to the prescriptive approach used in previous national programs such as TUSOME or PRIEDE. Furthermore, the XXXX targets specific skills versus general nature of the traditional instruction. The XXXX develop cross-curricular skills that are not explicitly addressed in the current curriculum (e.g., self-regulation). Finally, the XXXX offers a wide range of resources in English and some in Kiswahili.

Table 8. Summary of Codes by the Software Factors

Categories (number of ideas)	Number of sources	Number of coding references	% of total coding references
Total	*40*	*235*	
Bridges gaps (7)	22	14	5.96
Inadequacies (14)	25	42	17.87
Effectiveness (13)	28	42	17.88
Content (13)	22	38	16.17
Fit (7)	32	48	20.42
Design and features (19)	22	35	14.90
Student-centeredness (5)	10	16	6.81

The fit between the XXXX and educational context including the Competency-Based Curriculum, its goals and teaching schemes was reported most frequently (N=46). Not only the XXXX is well aligned with the paper-based national programs (e.g., PRIEDE) it also reinforces these programs as interactive learning technology that works on the government-provided tablets. The XXXX interactive content was commented to offer more than existing curricular materials and textbooks (N=21). In addition to interactivity, game-like design, potential for differentiated instruction and interoperability of the software on various devices and platforms were notes. Student-centeredness of the XXXX turned important (N=10) as it supports student autonomy, enable learning at one's own pace, sharing work and teaching each other.

The XXXX effectiveness was commended (N=27). The tools generate evidence of learning progress, enable teachers to motivate students, stimulate interest yielding important learning gains. After being exposed to the tool(s), younger students outperform older ones. Further, students continue to be interested in using XXXX even after they used it for some time.

Interviewees also commented about inadequacies they noted in XXXX tools. Lack of fit with the local language context, including accent; no access to the tools from home; lack of reading activities for older students; and ambiguity in the meaning of some concepts introduced in a tool were reported.

Individual Teacher Factors

Thirty-five participants commented about the teachers who would be inclined to teach with XXXX (Table 9). Interestingly, the teacher-interviewees gave minimum of opinions on the matter. Overall, the comments focused on dispositions and skills that the teacher-user of XXXX possesses.

Being the most important factor (N=29), the dispositions of the XXXX teacher include professional interest (N=12) and confidence, also in using ICT (N=11); ability and readiness to get out of the comfort zone (N=7); and passion (N=5). Teacher readiness to do extra work (N=6), commitment (N=3) and persistence (N=3), were also noted as drivers of sustainable use. On the opposite side of the spectrum are the teachers described as passive (N=7), technophobic (N=6) or questioning the purpose of teaching with ICT (N=3).

Table 9. Summary of Codes by Individual Teacher Factors

Categories (number of ideas)	Number of sources	Number of coding references	% of total coding references
Total	*35*	*175*	
Self-determination (1)	1	1	0.57
Self-efficacy (4)	18	22	13.57
Dispositions (29)	48	104	59.43
Skills and abilities (11)	21	31	17.71
Self-efficacy sources (2)	9	9	5.14
General observations (2)	2	2	1.14
Teacher age (1)	6	6	3.43

Contrary to the factors arising from affective domain, teacher capacity and skills were less reported. They include ability to use ICT and integrate it in instruction (N=12), and ability to train others (N=4) and

self-teach (N=2). The arrival of new generation of tech-savvy teachers was noted as a potential turning point for a large-scale acceptance of technology-based interventions (N=6).

Individual Student Factors

The comments about student factors that may affect teaching with the XXXX were rare (Table 10). Only 19 respondents, either a teacher or a school administrator, expressed up to 7 ideas. These rather related to the gains students got as a result of learning with the XXXX tools and included the increase in student autonomy (N=10) and engagement (N=9) and interest to learning (N=6). Together with improvements in student learning (N=6), progress in students' social skills, perseverance, capacity to peer-teach and even readiness to teach teachers were reported.

Table 10. Summary of Codes by Individual Student Factors

Categories (number of ideas)	Number of sources	Number of coding references	% of total coding references
Total	*19*	*70*	
Disposition (6)	11	16	22.86
Skills and abilities (9)	13	16	22.86
Benefits for students (7)	23	38	54.29

Some respondents stated that weaker students required more time to learn with the tool. Others yet suggested that student individual differences did not matter, instead it is the teachers who should be able to manage (N=3). At the same time, successful XXXX students are tech savvy and excited by ICT (N=11).

The case where some secondary students used their lunch break to do the portfolio work in the computer lab was reported as an example (N=2).

Factor Effects

We also investigated what factors might have influenced the teachers' intent to continue or stop using the XXXX in their practice. First, we applied expectation-value framework which reduces teaching with technology to a simple teacher motivation equation (Authors, 2006). The composite variable of the teacher Motivation to Sustain XXXX Use was created by aggregating the number of coding references within each of the three categories of value (M=3.05, SD=2.22), expectations (M=2.75, SD=1.90) and costs (M=2.13, SD=1.59) per respondent and letting them enter the equation expectancy + value -- cost of use. The resulting motivation mean score and the standard deviation were 5.25 and 3.76 respectively (Table 13). We calculated continuous composite scores for the 8 factors by combining together the subcategories within each factor. We hypothesized that the factors directly predict practitioner's intent to continue or stop using XXXX. Additionally, we assumed that Teacher Factors can be directly predicted by Professional Development, Student and School Factors and serve as an intervening variable between the three sets of factors and teacher motivation to sustain the XXXX Use. The correlation coefficients support this

assumption (Table 13) showing significant positive relationship between a) PD and School Factors and Teacher Factors, and b) Teacher Factors, PD and School Factors and Motivation to Sustain the XXXX Use.

Table 13. Means, Standard Deviations, and Correlations of Eight Factors and Motivation to Sustain Using LTK

	1	2	3	4	5	6	7	8	M	SD
1. Motivation to sustain use of LTK									5.25	3.76
2. Economic Factors	.154								2.20	1.85
3. Technology Factors	.092	.462**							2.90	2.45
4. Policy Factors	.231	.070	.302						1.85	1.61
5. Software Factors	.107	-.025	.208	.204					5.55	3.49
6. School Factors	.322*	-.124	-.109	-.113	.141				7.30	3.81
7. PD Factors	.363*	.017	.039	-.011	.047	.297			3.15	3.11
8. Teacher Factors	.351*	-.058	.254	-.018	.096	.483**	.444**		4.33	3.94
9. Student Factors	.297	.068	.092	-.051	.066	.111	.009	.449**	0.65	0.98

**p< 0.01; *p< 0.05

AMOS path analysis generated support for the hypothesized model with the chi-square index of 25.905 (df=24), p=.358. The Goodness-of-fit indices also implied a reasonably well-fitting model. The Comparative Fit Index (CFI) of 0.96 was robust. The Root Mean Square Error of Approximation index (RMSEA) was 0.045 (p=.458) with the confidence intervals of 0.000 and 0.140. Such combination of RMSEA and confidence intervals suggest an acceptable precision of the model. There was no evidence of the model misfit: two modification indices (MI < 20; parameter change < .10) suggested that the

hypothesized model is appropriately described; the highest standardized residuals was 1.88 below critical value of 2.58. The hypothesized model is in Figure 1 whereas Table 14 summarizes the model effects.

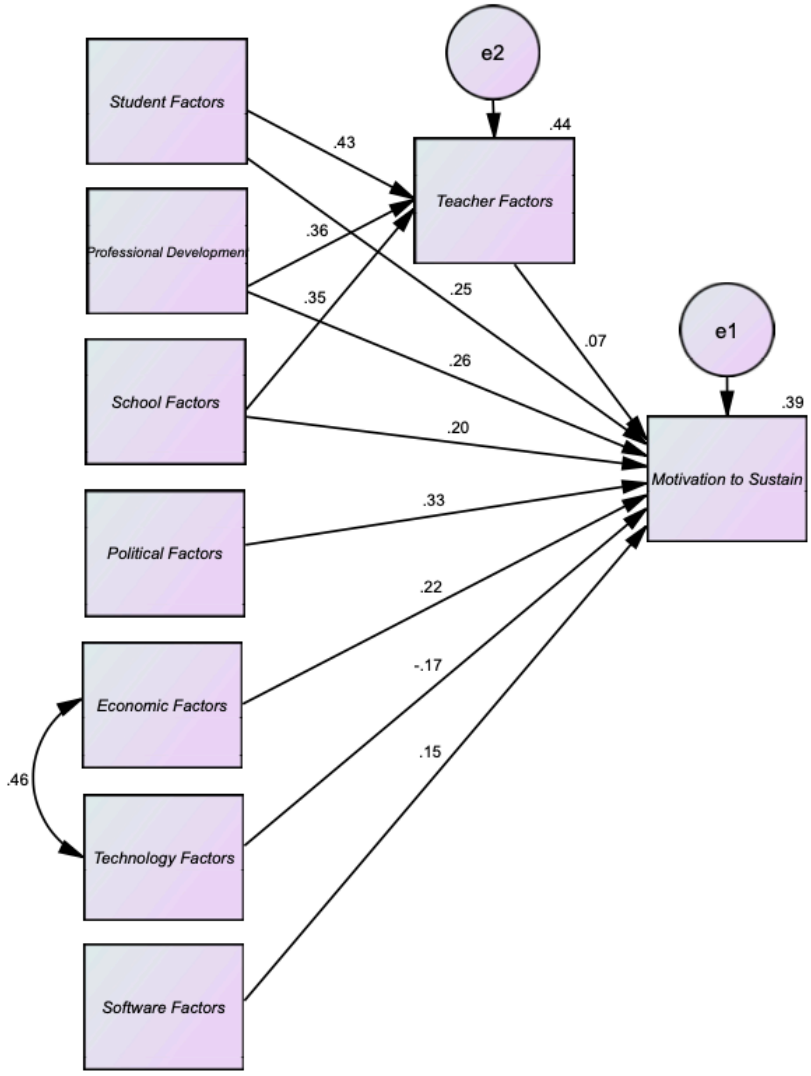

Figure 1. Effects on Teacher Motivation to Sustain Use of LTK Path Model

The eight factors accounted for 39% of the variance in the motivation to sustain the XXXX use. The effects of the seven exogenous factors within the model were mixed. Increased motivation to sustain the use of XXXX was significantly predicted by Policy and Professional Development factors, the

standardized coefficients were 0.34 and 0.27 respectively, whereas the remaining five factors did not have significant direct effects.

Table 14. Decomposition of Effects

	Factors							
	PD	Student	School	Teacher	Policy	Economic	Technology	Software
Standardized direct effects								
Teacher Factors	0.359*	0.431**	0.355*					
Motivation to sustain	0.265*	0.245	0.204	0.065	0.335*	0.220	-0.172	0.151
Standardized indirect effects								
Motivation to sustain	0.023	0.028	0.023					
Standardized total effects								
Motivation to sustain	0.288*	0.274*	0.227	0.065	0.335*	0.220	-0.172	0.151

**p< 0.01; *p< 0.05

Except Technology factors whose effect was negative, the other factors' influences were positive. Student, School and Professional Development factors each had a strong direct significant effect collectively explaining 46% of variance of the only moderator, Teacher factors. The respective coefficients were 0.43, 0.35 and 0.39. Yet, Teacher factors minimally contributed to the variation in a teacher's intent to sustain the XXXX use (β=0.065). After controlling for the mediator, the indirect effects of the Student, School and Professional Development factors on the intent to sustain use were positive but small and not statistically significant. The total effects were statistically significant for Policy, Professional Development and Student Factors implying that each one-point increase in reporting them would rise motivation by 0.34, 0.29 and 0.27 per unit respectively. Except for the strong and significant relationship with Teacher factors,

School influences did not turn significant for the motivation to sustain the use of XXXX; neither did Economic, Technology and Software Factors.

Discussion

This paper reports the findings from the interviews of 40 teachers, school headteachers, and partners involved in implementing the XXXX, an evidence-based learning technology, where we explored perceptions and experiences in order to understand the factors believed to influence adoption and further use of this educational technology.

The individual teacher's agency in making the difference in the classroom, the school, and eventually, the whole system is the cornerstone of this study. Our prior research confirmed the importance of the motivational disposition of innovators (Authors, 2006). In particular, teachers who have high expectations of successful implementation, who perceive minimal costs to implementation, but see the value-added of implementation are those who persevere. However, insuring a quality and efficacious educational implementation, and then finding ways to sustain and scale it, are subject to many challenges and opportunities. Among the influences we explored, the Policy, Professional Development and Student factors explained an important portion of the self-reported intent to continue using the XXXX software.

Political context turned out the most influential antecedent of teacher motivation. As determined decisions and actions taken by government, unions, parents and other interest groups, educational policies

shape the direction and development of the entire education system and, therefore, practices of schools and teachers. Indeed, for teachers to sustain an intervention, its pedagogical objectives and implementation resources had to be aligned with national policies, curriculum and local educational priorities. Such alignment was especially important in Kenya context since the implementation rolled out in the time of the massive curricular reform including nationwide initiatives. In practice, the XXXX training and support emphasize how the tools are not in rivalry with the above programs but rather a complementary effective vehicle to achieve the nationally-owned educational objectives.

Professional development factors had important and universal effects on teacher motivation as well as their skills and dispositions. Our practices rely increasingly on constantly evolving training and follow-up support including the institute of roving and school-based ambassadors and a system of scaffolds embedded in and supplemented to the software. Since the capacity of actors involved in implementation vary, both training and support addressed the teachers' needs in technical, pedagogical and content knowledge (e.g., Mishra & Kohler, 2006). The sought-for outcomes did not limit to mere adoption of computer technologies but targeted teacher's understanding of the core principles of the XXXX pedagogy and autonomy in applying these principles in instruction to encourage advanced modes of learning and teaching. Regular meetings to share experiences and plan teaching with XXXX ensured teacher gains from peer learning. Having expert users of XXXX tools themselves, participate in these meetings benefited

teachers and, especially, neophytes. Not only did they modelled school contexts but they addressed the uncertainties of those just starting out by illustrating their own success in beginner-like contexts. In addition, professional development was a motivator because formal XXXX certification, recognized by the national Teacher Service Commission, helped the progression of teacher career or as Bennell and Akyampong (2007) suggested it offered an opening for teachers to escape drudgery of their classroom.

The influence of *student* factors was consistently important on both teacher motivation and capacity to sustain LTK tools in their teaching. It is students' experiences with the tools that increased their autonomy, engagement and interest to learning and drove their teachers' enthusiasm and intent to continue using the tool. Further, since students were quite vocal about their teachers' use of the software for teaching, this might have prompted teachers to improve their capacity and efforts to integrate technology.

The influence of *school* turned significant on teacher dispositions rather than their intent to continue teaching with the XXXX. Research argues that successful initiatives are linked to the extent to which the school community takes responsibility for them (Pouezevara et al., 2014). Including the use of XXXX into schools plans and schedules explicitly confirmed the alignment between the curriculum and the tool and also demonstrated the commitment of the school leaders to the intervention. This translated into allocating school resources to support implementation such as liberating teachers, scheduling computer lab sessions, paying bills for electricity and maintenance. Yet, some headteachers percieve technology as costly without

evident short-term returns consuming limited funds that schools have, distracting teacher's time instead (Mingaine, 2013). In this regard, addressing the needs of the school community, providing adequate and timely in-school support, creating ownership and managing expectations are critical for technology adoption.

Despite the important contribution of influences from students, professional development opportunities and school environment, *teacher* factors turned out to have little direct effect on a teacher intent to use the XXXX tools. Whereas teacher skills and abilities are a natural case for training and professional development, teacher dispositions make a special case. They can potentially drive the intent to change practice but only to a limit. While many teachers become involved in implementing technology because they feel their personal effort is worthwhile regardless of whether or not they receive support from the system, yet a longstanding change cannot be maintained through teacher commitment alone (Salinas et al., 2017). For if the effort must be sustained for too long, it is likely that the enthusiasm of these teachers will wain and they will no longer be able to sustain a complicated process of the innovation use. As a result, teachers may assign greater importance to the external agency of the centralized system and its policies, rather than their own capacity and skill.

In conclusion, the usefulness of these findings is three-fold. First, this study generated results that are practical in the context where the existing research is far from providing evidence-based principles to

build sustainable and scalable educational interventions in developing countries (Robinson et al., 2017). And even more so, since the research tends to follow the evolution of relatively large initiatives into educational mainstream while assigning little interest to how an intervention proven successful with a handful of teachers and students grows to reach many in dire need of it. Second, the tested model validated the results from the qualitative interviews, suggesting paths associating a range of external and internal factors with sustainable uses of XXXX tools where motivation served a shortcut for durable implementation. Although it is also likely that other factors not included in this model, measurement error, coder bias, and small sample size, also had their effects. Third, the model points to the priority directions for technology-based pedagogical innovations to endure and expand in developing context such as seeking support from the local and national governments and enhancing teacher professional development in order to strengthen individual and collective capacity. Finally, the results of this study suggest the need to advance our research agenda. For instance, since spreading beyond a few schools raises strategically different issues for the project, it will be necessary to learn how we can effectively thread the XXXX related ideas throughout the local and national educational authorities to establish long-term support and ensure that the activities fit the short- and long-term strategies of the authorities even if their priorities change.

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